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## REPORT TO THE FISH AND GAME COMMISSION:

## A STATUS REVIEW OF THE

## DELTA SMELT (*HYPOMESUS TRANSPACIFICUS*)

## IN CALIFORNIA


DEPARTMENT OF FISH AND GAME

State of California
The Resources Agency


April 1993

smelt are euryhaline and much of the year are typically most abundant in or immediately upstream from the entrapment zone, where incoming saltwater and outflowing freshwater mix. This species feeds exclusively on zooplankton, spawns in freshwater, and usually only lives for one year.

Information from seven different data sets all indicate that the population of delta smelt has declined substantially since the late 1970s or early 1980s. The summer townet survey indicates that the average population since 1982 has been less than one-sixth of the average population level from 1959, when the survey began, to 1981, and the population in 1992 was less than one-eighth of that average. Based on the fall midwater trawl survey, the average population since 1982 has been less than one-third of the average population level from the initial survey in 1967 to 1981, and the population in 1992 was less than one-fifth of that average.

Conclusions

The Department finds that the delta smelt should be listed as a threatened species, based on Section 670.1(b) of Title 14 of the California Code of Regulations and Section 2072.3 of the Fish and Game Code. The Department's findings are based on the following:

1. While the relationship between delta smelt abundance and water diversions is not

clear, all life stages of delta smelt are vulnerable to entrainment in these diversions. Large losses of pre-spawning adult smelt entrained when the major water projects escalate pumping in winters following major droughts (eg. 1977-1978) may be particularly harmful. It is relevant that delta smelt are ecologically similar to young striped bass which have been severely impacted by water diversions. Whether or not water diversions are directly responsible for the delta smelt population decline, their drain on the population may be a significant factor inhibiting recovery.

2. The recent decline in the copepod, Eurytemora affinis, a major diet component of the delta smelt, must be considered as a potential threat to the smelt's recovery unless other food resources such as Pseudodiaptomus forbesi compensate or Eurytemora recovers to its former abundance.

3. Low spawning stock levels may inhibit potential for population recovery. The relatively low fecundity of this species and its planktonic larvae, which undoubtedly incur high rates of mortality, indicate that year class success of the delta smelt must depend on reproduction by fairly large numbers of fish.

4. A number of exotic fish and invertebrate species have been introduced into the Sacramento-San Joaquin Estuary. Although none of these species can be directly linked to the decline in delta smelt, their presence may inhibit the smelt's recovery.

5. The years of the delta smelt decline are characterized either by outflows that were too low to transport young fish to their optimum habitat in Suisun Bay, or by exceptionally high outflows that may have transported larvae beyond Suisun Bay into the western estuary.

6. The wakasagi, a closely related species introduced into several reservoirs in the Delta drainage has now been found in the American River below Nimbus Dam. The wakasagi potentially could compete with the delta smelt or hybridize with it and dilute its gene pool.

7. Although there is no direct evidence of delta smelt suffering direct mortality or stress from toxic substances, such substances cannot be eliminated as having adverse effects on the population.

8. Diseases and parasites of delta smelt have never been studied; thus, there is no evidence concerning their role in the population decline. After several years of intense study on all aspects of the life history of delta smelt there has been no evidence that disease or parasites have played a role in the decline of this species. However, should they be found to be important, they could prevent the recovery of delta smelt from current low population levels.

9. Although competition and predation cannot be ruled out as threats to delta smelt, the

available evidence suggests that they are not a major threat. In fact, several potential competitors or predators also show signs of population erosion approximately coinciding with or preceding the decline of delta smelt.

10. The delta smelt population trend, certain life history attributes, and environmental threats tend to support listing. The scientific information is insufficient, however, to determine whether the population is low enough that it is in imminent danger of extinction. This is a complicated scientific determination, and no study which might be implemented will provide a conclusive answer in the next few years. Meanwhile, the population might become extinct. The most prudent action, therefore, is to list the delta smelt as a threatened species.

## Low Spawning Stock

Our evaluation of factors regulating delta smelt abundance failed to show that spawning stock abundance had a major influence on delta smelt year class success (pages 52 to 56). Nevertheless, the relatively low fecundity of this species and their planktonic larvae, which undoubtedly incur high rates of mortality, means that annual reproduction must be accomplished by fairly large numbers of fish if the population is to perpetuate itself (Moyle and Herbold 1989). Thus, while the stock abundance may not have been an important factor in the past, present or future low stock levels may inhibit potential for population recovery. Pimm et al. (1988) show that small species with variable populations, like delta smelt, become increasingly vulnerable to extinction as their populations decrease.

## Entrainment in Water Diversions

Delta smelt larvae are lost to entrainment in water diversions of the CVP, SWP, and Delta agriculture, the Pacific Gas and Electric Company (PGE) and other industry using water from the Estuary.

The PGE power plant intakes are screened, but these screens are ineffective on larval fish. In 1978-1979, more than 50 million and 16 million smelt larvae (delta smelt & longfin smelt --

larval smelt are difficult to identify to species and there has not been an attempt to identify them during any of the entrainment monitoring programs) were estimated to have been entrained at PGE's Pittsburg and Contra Costa power plants, respectively (PGE 1981a, 1981b). Also, estimates of impingement of larger delta smelt juveniles on the power plant intake screens were 11,000 fish at Pittsburg and 6,400 fish at Contra Costa.

There is no information available on delta smelt losses in the myriad of delta agriculture diversions which are not screened at all. However, during sampling on 20 days from November 1980-May 1981 and September 1981-March 1982, the delta smelt was the most numerous species entrained in the unscreened Roaring River Slough diversion from Montezuma Slough for water distribution in the Suisun Marsh (Pickard et al. 1982). This sampling, which generally consisted of placing a net over 1 of 8 intake culverts for several hours, captured 5,841 delta smelt.

Substantial entrainment losses also occur at the CVP and SWP despite their intakes being miles from the primary spawning and nursery areas. These losses occur due to the magnitude of the water project diversions, their impact on Delta flow patterns, and the tendency for young delta smelt to be transported and dispersed by river and estuarine currents.

The CVP and SWP pumps are located at the southern edge of the Delta, but pumping rates usually exceed the flow of the San Joaquin River entering the Delta from the south; therefore, most of the water that they export must come from the Sacramento River. Approximately the first 3,500 cfs of flow exported from the Sacramento River crosses the Delta through the CVP's Delta Cross Channel and Georgiana Slough near Walnut Grove and flows to the pumps through natural channels upstream from the mouth of the San Joaquin River. Young smelt that were spawned in the water transport channels or in the Sacramento River upstream from Walnut Grove would be particularly vulnerable to this water management scheme. At higher export rates, water is drawn up the San Joaquin River from its junction with the Sacramento River (Figure 19). Such net upstream flows in the San Joaquin River are typical in all but wet springs, and in the summer and fall of all years. The upstream flows entrain young smelt from the western Delta and carry them to the water project intakes.

Moyle and Herbold (1989) found that high frequencies of reverse flows in the San Joaquin River during spring were always associated with low abundances of delta smelt in Suisun Bay in the fall (Figure 20) while low frequencies of reverse flows sometimes were associated with high abundances of delta smelt. They (MS) also point to a trend of increasing reverse flows in the San Joaquin River, especially during the spawning months.

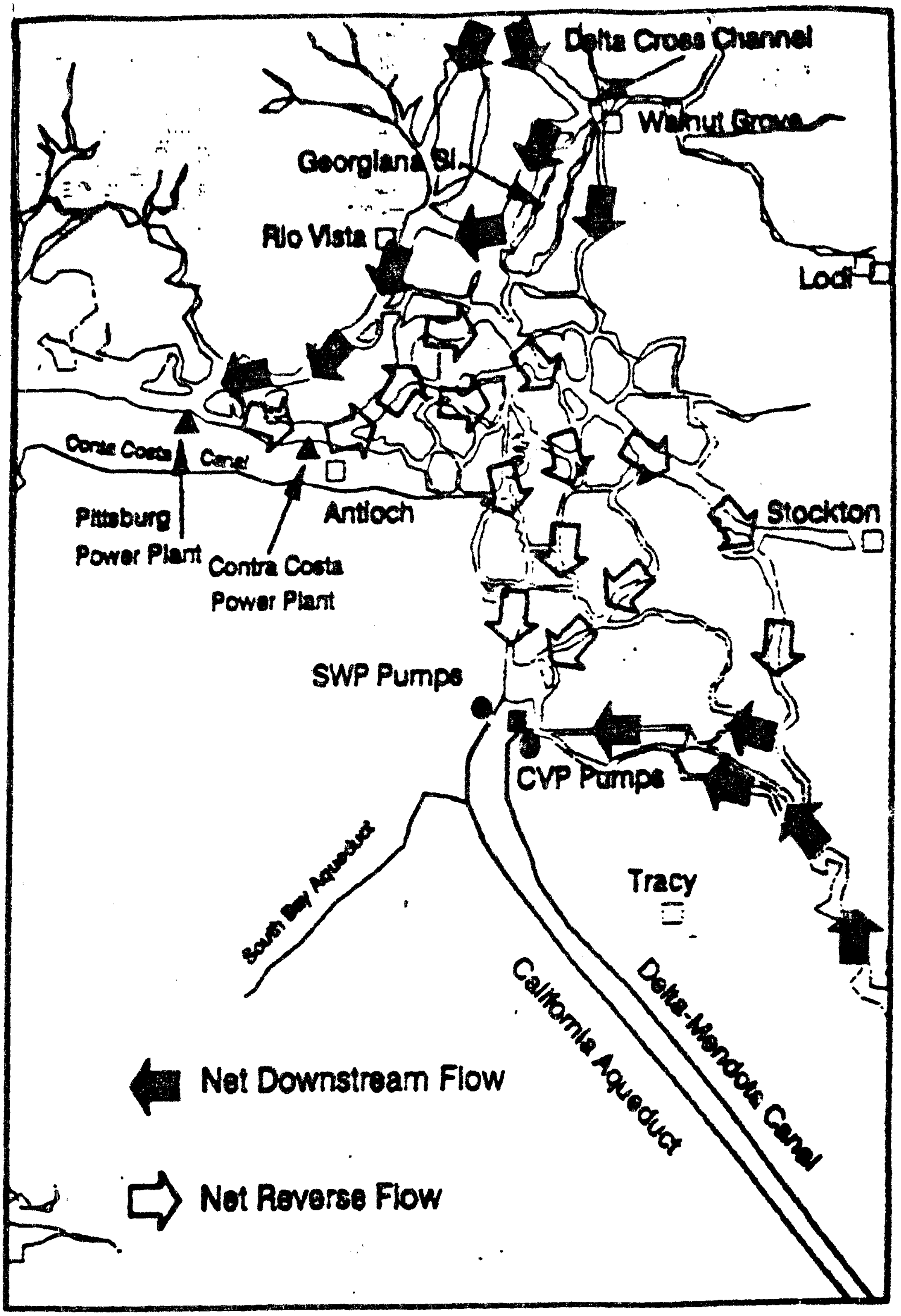


Figure 19. Typical summer flow patterns in the Sacramento-San Joaquin Delta. CVP-SWP export pumping has changed the natural flow patterns. Reverse flows transport many delta smelt from their nursery to the CVP-SWP diversions in the south Delta.

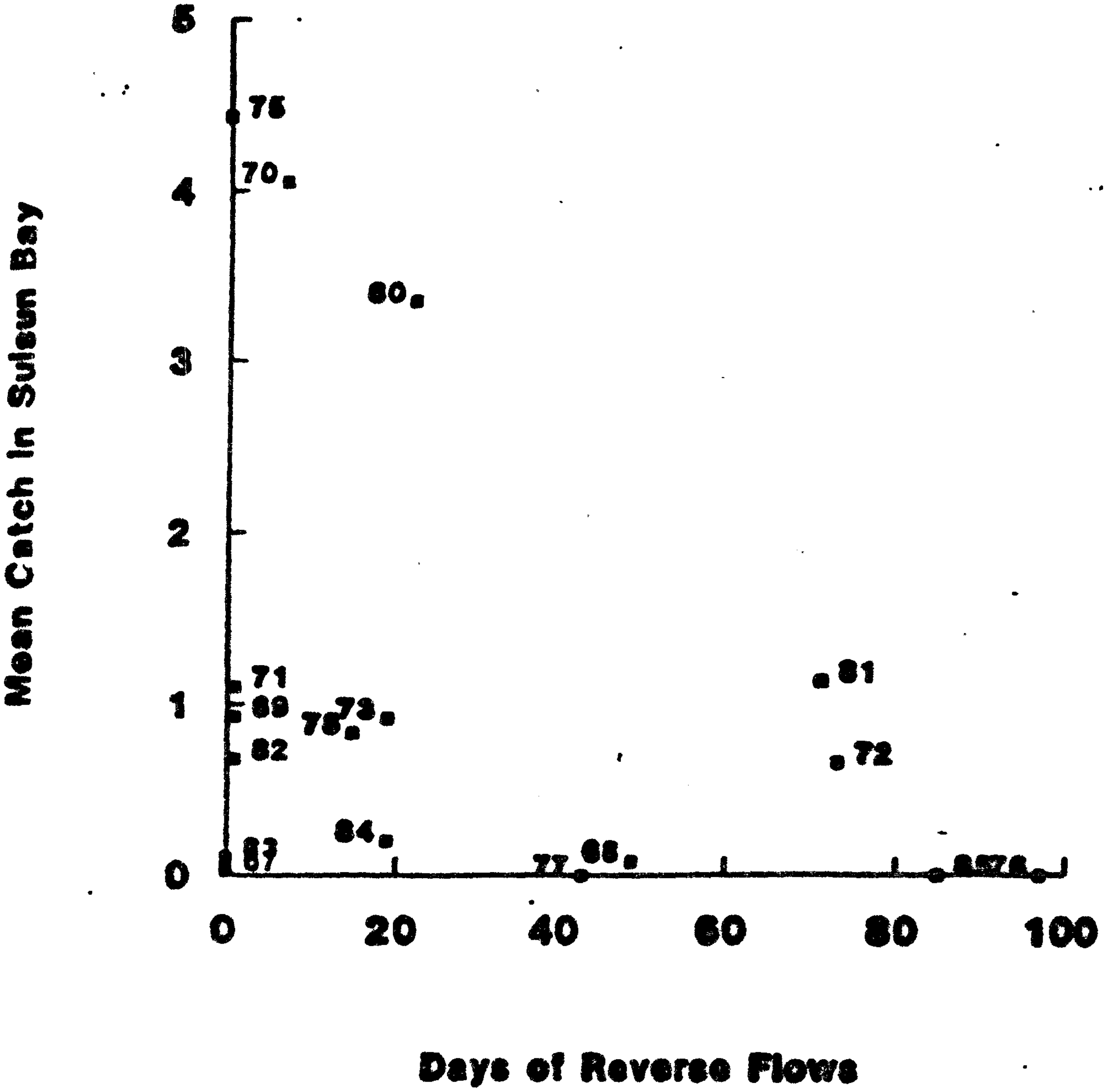


Figure 20. Mean Densities of fall populations of Delta smelt in Suisun Bay vs. numbers of days of reverse flows in the San Joaquin River during March to June. From Moyle and Herbold (1989).

such, an association between reverse flows and smelt abundance is conceptually reasonable although it may, at least partly, reflect other correlated impacts of low river inflows or outflows. The sometimes low abundance indices at low reverse flows and the lack of association between reverse flows and smelt since 1983 indicate that reverse flows are not the sole mechanism driving the delta smelt population. A plot using the total population index is similar to that for the Suisun Bay portion, except for 1972 when delta smelt abundance was high despite 72 days of reverse flows during March-June (Figure 21).

Even when the net flow of the lower San Joaquin River is not reversed, net flow usually is still reversed in the southern Delta; thus, deltawide, there is dispersal of fish associated with the ever changing tides which maintains their exposure to entrainment by the CVP and SWP. The reverse flow of the southern Delta draws young fish and their food organisms out of the spawning and nursery areas to the north and transports them to the diversion sites.

The louver screens in front of the SWP and CVP pumps guide many of the young fish to holding tanks and tank trucks in which they are transported back to the western Delta and released. However, numerous fish, particularly larvae and others too small to swim well, pass through the screens and are lost into the aqueduct

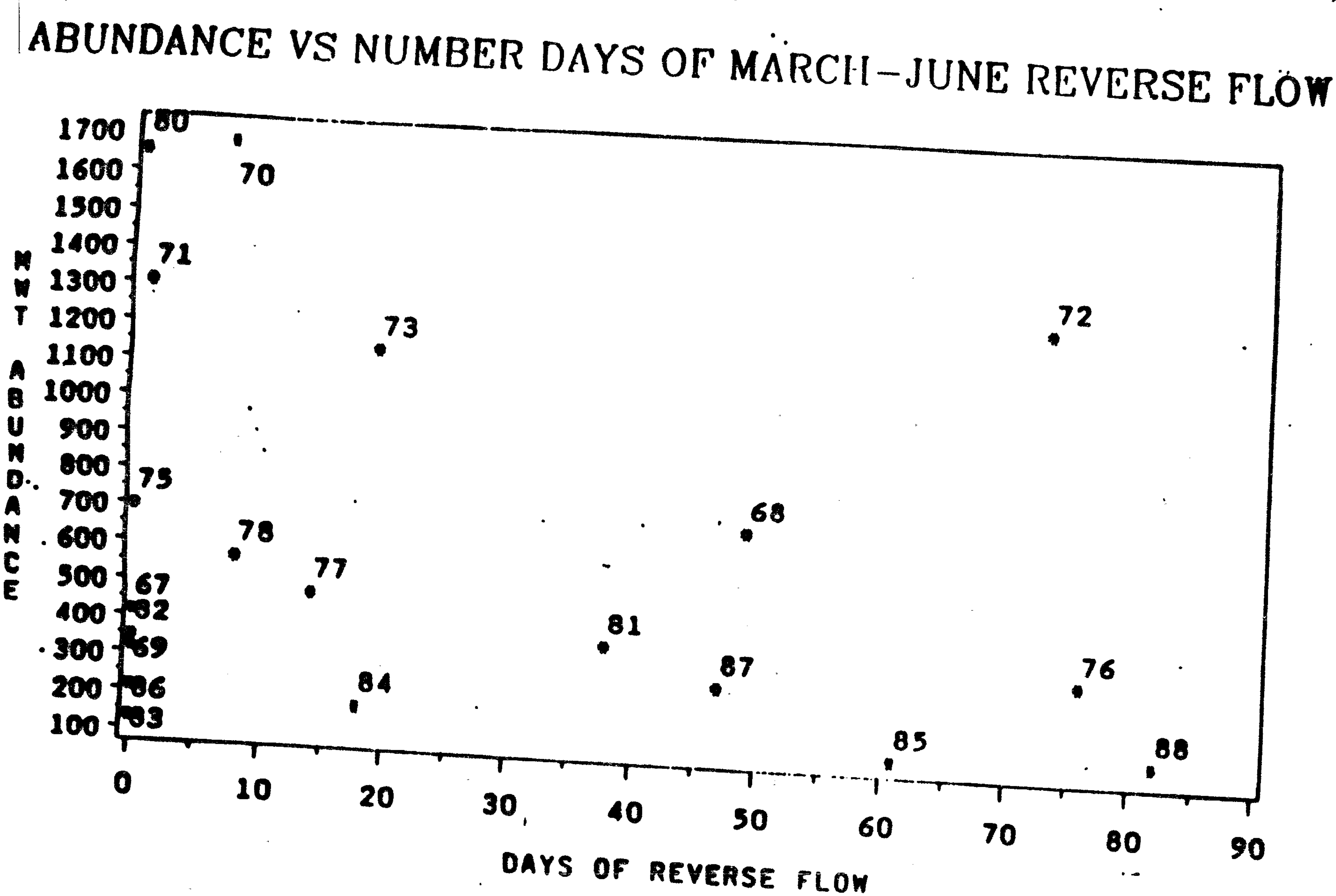


Figure 21. Relationship between fall midwater trawl index of delta smelt abundance and the number of days of reverse flows in the Lower San Joaquin River from March to June.

system. Substantial numbers of the many young delta smelt that are salvaged (pages 31 to 41) also die due to stresses received during the handling and trucking. Others are eaten by larger fish in the SWP's Clifton Court Forebay and near the trash racks at both the CVP and SWP screens. These factors have not been evaluated for delta smelt but are known to be significant detriments to striped bass (DFG 1987).

Delta smelt are most vulnerable to entrainment during spring and summer as shown by the number salvaged per-acre-foot of exports by the SWP (Figure 22). This pattern reflects the late winter-spring spawning season and growth and mortality of young fish. During April and May, abundance of young smelt at the SWP and CVP diversions probably is greater than shown in Figure 22. However, this tendency is not displayed by the salvage estimates because the smelt are so small that they pass through the screens and are not salvaged during the first month or two of life. Also, smaller smelt are not readily identifiable by the technicians responsible for sampling salvaged fish.

The intra-year salvage pattern in 1977-1978 was a notable exception to the typical pattern. Through much of 1977, water exports were reduced, due to a major drought, and while a delta smelt salvage peak occurred in July, the greatest entrainment and salvage of the 1977 year class occurred from December 1977

# Mean Monthly CPUE at SWP and CVP

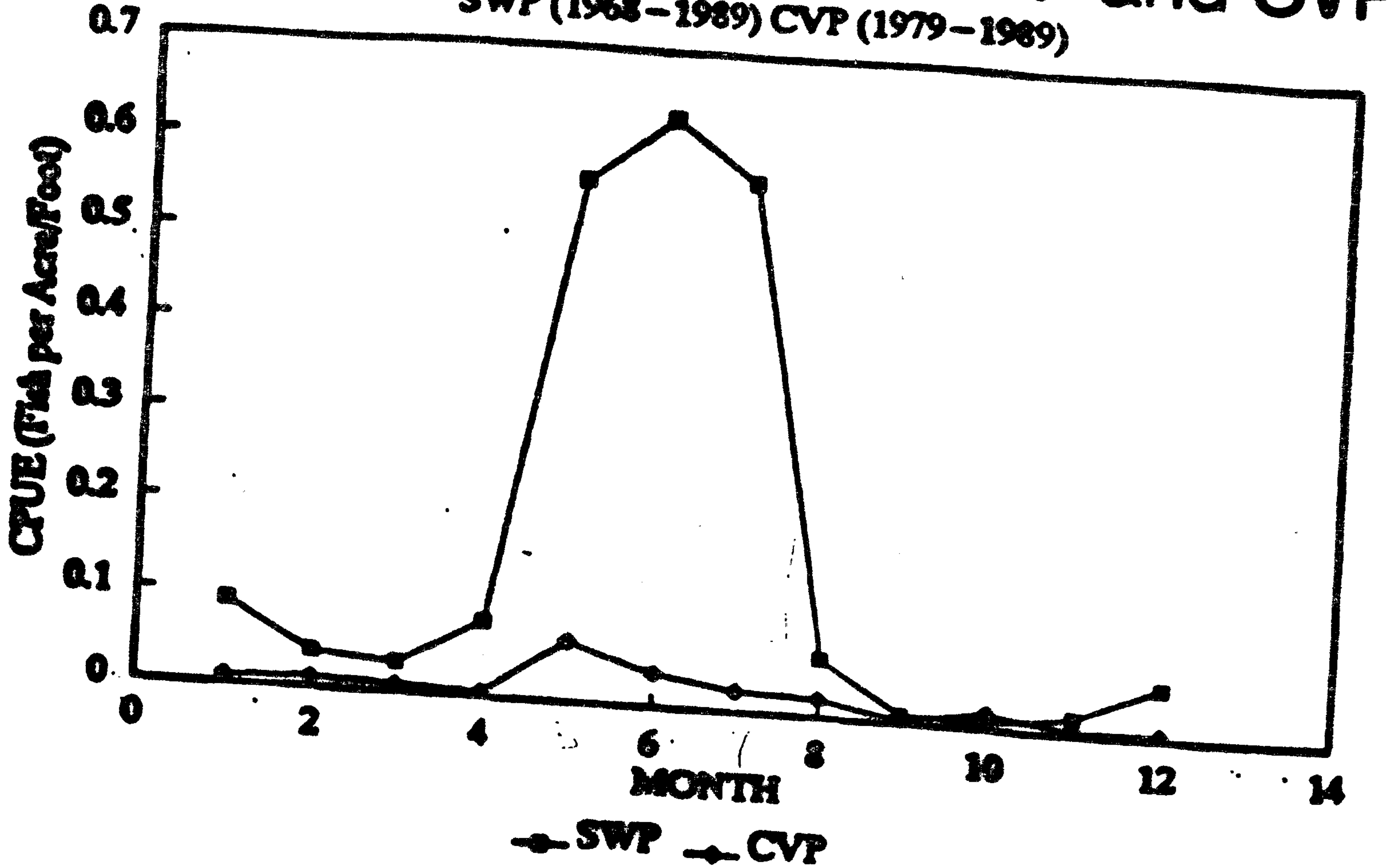


Figure 22. Mean monthly salvage of delta smelt per acre foot of water diverted by the State Water Project and Central Valley Project.

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through February 1978 when water exports increased after the drought broke (Table 15). In fact, the salvage of 134,000 delta smelt at the SWP in January 1978 almost equaled the total for allof 1977 (146,000 fish) and exceeds the annual totals for all subsequent years.

What is the importance of entrainment losses with respect to the population decline of delta smelt? This is unclear. Comparisons of estimated population levels (Table 13) and salvage estimates (Figures 4, 8 and 9) suggest entrainment losses potentially could cause major reductions in delta smelt abundance. The greatest annual salvage, and probably losses, to water project diversions occurred from 1970 to 1976 (Figure 8). Considering that few delta smelt live beyond 1 year, if such entrainment depleted the population, the impact should be noticeable the following year. Yet the population apparently did not crash until 1983, 13 years after 1970, the initial year of record with a major salvage. Also, looking at the salvage data alone, one might hypothesize that the unusual entrainment of maturing adults in 1977-1978 had critically depleted the stock, but again this hypothesis is inconsistent with the population trend depicted by the more comprehensive trawl and townet survey indices.

Nevertheless, delta smelt are ecologically similar to young striped bass which have been severely impacted by water

Table 15. Estimated Salvage of Delta Smelt and Water Exports at the State Water Project diversion in the southern delta, during 1977-1978.

| | Month | Delta Smelt Salvage | Exports (thou. acre ft) |
|---|---|---|---|
| 1977 | Jan | 6980 | 205 |
| | Feb | 2430 | 106 |
| | Mar | 1707 | 97 |
| | Apr | 2975 | 14 |
| | May | 3017 | 68 |
| | Jun | 3033 | 17 |
| | Jul | 43489 | 20 |
| | Aug | 6435 | 15 |
| | Sep | 17890 | 9 |
| | Oct | 2528 | 8 |
| | Nov | 350 | 51 |
| | Dec | 55101 | 224 |
| 1978 | Jan | 134089 | 365 |
| | Feb | 53960 | 343 |
| | Mar | 4217 | 108 |
| | Apr | 130 | 35 |
| | May | 3523 | 59 |
| | Jun | 36289 | 201 |
| | Jul | 1034 | 211 |
| | Aug | 2658 | 246 |
| | Sep | 244 | 211 |
| | Oct | 60 | 127 |
| | Nov | 473 | 131 |
| | Dec | 900 | 169 |

diversions (CDFG 1987, Stevens et al. MS.). Delta smelt are vulnerable to diversions throughout their life cycle, particularly in dry years, when they are concentrated in the Delta from which the water is diverted. Thus, even if water diversions were not directly responsible for the delta smelt population decline, their drain on the population may be a significant factor inhibiting recovery.

## Toxic Substances

Dr. Moyle's petition points out that the Estuary receives a variety of toxic substances, including agricultural pesticides, heavy metals, and other products of our urbanized society. The effects of these compounds on delta smelt have never been tested, and their effects on fishes in general are poorly understood. Some of these substances are known to occur in the Estuary's fishes at levels that may inhibit their reproduction (Jung et. al 1984) or are sufficient to trigger health warnings (e.g. Mercury in striped bass) regarding human consumption. Also, recent bioassays by the Central Valley Regional Water Quality Control Board (Foe 1989) suggest that water in the Sacramento River is, at times, toxic to larvae of the fathead minnow, a standard EPA test organism . However, the timing of the delta smelt decline is not consistent with the increased, mid-to late-1970s, use of the chemicals thought to cause mortality in these bioassays.

Table 16. Probable Trend in Delta Smelt Population Threats. W = worse, S = Stable

| Threat | Trend |
|---|---|
| Inadequate Food Supply | S |
| Inadequate spawning stock | S or W |
| Entrainment Losses | W |
| Toxicity | ? |
| Delta outflows | W |
| Genetic dilution | S |
| Exotic introductions | S (if ship ballast discharges are controlled), W (if ship ballast discharges are not controlled) |
| Disease and parasites | S or W |





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